structure may be seen to curve round and cross the centre of the glacier, forming great loops directed down-stream. The veining and ribboned structure are nearly parallel with the sides and bottom of the glacier, and where the surface is being rapidly melted the lower horizontal veins near the middle come to the surface and form these loops. Forbes appears to be quite correct when he says "the vertical structure is too close to the original strata of the *névé* to allow of the supposition that these have all of a sudden turned up vertically in some parts of the glacier, and disappeared in the remainder".

In the cave which was made in the lower portion (which has now melted away) of the Upper Grindelwald glacier I have seen the ice built up of more or less regular layers of flat ice granules, the whole appearing like a mass of masonry or ribbons of grains. The shear-planes cutting the granules and giving rise to this ribboning are produced by slow shear without fracture parallel to the direction of flow. This regular structure produced by shear is not commonly seen in ice caves, for they are generally excavated at the ends of glaciers where the rate of distortion is small. Where this masonry-like structure crops out on the glacier it discloses itself as ribboned structure. As before remarked it is generally parallel with the veined structure, and seems to make it more striking. On the Rhone glacier the ribboned structure is shown up by the dirt which settles in the parallel fissures produced by the melting of the ice along the shear-planes. Where streams cut into the ice it is frequently well shown.

Both the veined and ribboned structure will be found most perfectly developed when the glacier is moving rapidly and the internal strains, i.e. rate of distortion, is greatest. When a glacier widens, becomes thin, or for any reason moves slowly, the slow alterations which are constantly taking place in the shape of the grains gradually obliterates the structure. Owing to the motion the structure is also carried to portions lower down the glacier than those where it is being produced, and in crevassed areas the veins and ribboned structure are twisted about in a very striking manner. The time required for the grains to appreciably alter their form and size must be measured in years.

II.—On the discovery of Bembridge Limestone Fossils on Creechbarrow Hill, Isle of Purbeck.

By Henry Keeping, Sedgwick Museum, Cambridge.

(PLATE XXXIV.)

WHEN last year I had an opportunity of examining a few rocks and fossils from the limestone of Creechbarrow Hill, which the late Mr. W. H. Hudleston considered of Bagshot age, I at once suspected that they belonged to the Bembridge Limestone. Upon my pointing this out to Professor Hughes he requested me to go down to examine the ground, which I did in November of last year, but I found only the same fossils which Mr. Hudleston had recorded, namely, *Melanopsis* and *Paludina*. On my return to Cambridge I expressed the opinion that better evidence would probably be obtained if a few openings were made here and there, and the Professor arranged that

I should carry out a further examination of the area at a more convenient season. This I have done, and I now offer the results of my further researches.

After getting permission from the owner of the land, G. W. Bond, Esq., and his tenant, Mr. Trent, I commenced by making an opening on the south side, and also spent some time in the pit which Mr. Hudleston had made, but I found only the same fossils as on my last visit. Feeling sure that the limestone must be found at a lower level I opened another pit, about 12 feet long, at the base of the limestone. At one end of this pit I found a reddish marl called by the workmen Cherry Marl, which I refer to the Osborne formation. Few or no fossils are ever found in this marl. At the end nearest the top of the hill we came on the base of the limestone resting on the marls. I recognized the section as exactly similar to that in which the vertebrate remains were found in the Isle of Wight, and examined it carefully. In about ten or twelve minutes I found part of the tooth of a *Palæotherium*. Unfortunately I had only about a yard of this bed exposed, but I feel sure from the character of the deposit that more mammalian remains might be obtained here. I then opened

Diagram Section showing the relation of the Creechbarrow Limestone to the underlying series : *a*, Bembridge Limestone ; *b*, Osborne Series ; *c*, Upper Headon Series ; *d*, Middle ditto ; *e*, Lower ditto ; *f*, Sands ; *g*, Barton Beds; *h*, Brackleham Beds with lignite ; *i*, Bagshot Beds with pipeclay ; *j*, London Clay ; *k*, Woolwich and Reading Beds ; *l*, Chalk.

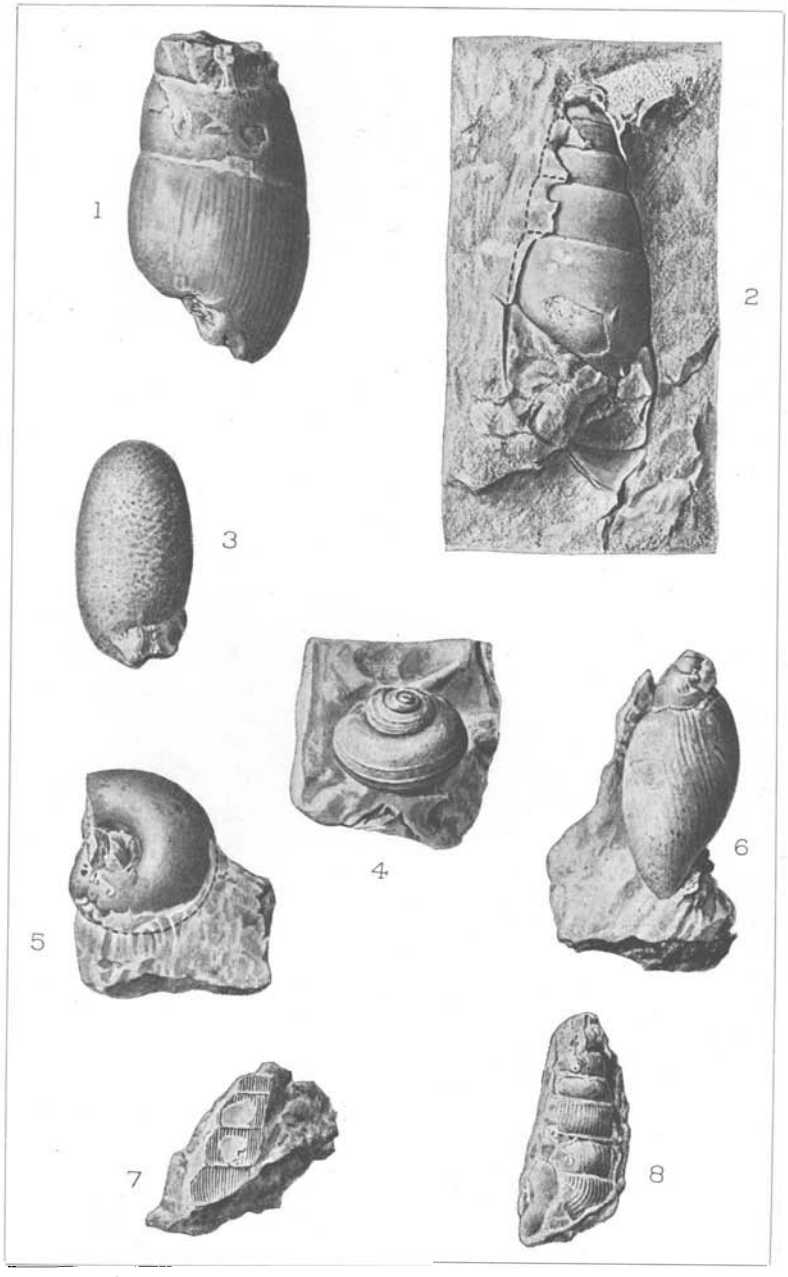
another pit on the north side of the limestone, and after reaching a depth of about 7 feet I found what I had been looking for, namely, beds of limestone which I would refer to a lower horizon in the Bembridge Series. These yielded good results, as I obtained from them *Bulimus* (two species), *Cyclotus* (two species), *Helix* (two species), *Clausilia* (two species), *Achatina costellata*, and the so-called eggs of *Bulimus*: altogether about twenty species, some of which have not yet been determined. The marls in the old excavations, still to be seen some way down the hill-side, which were explained by Mr. Hudleston as due to the crumbling away or waste of the limestone from the top of the hill, I believe are part of the Lower Headon Series, from which marl was formerly dug for manuring the land. A good dressing of this was supposed to last from seven to ten years. The marl of Creechbarrow is, however, much more sandy than any I have seen in the corresponding beds elsewhere. When I was a boy of seven or eight years of age I should say there could not have been less than fifty men employed at this work. I have many times watched them digging, and they occasionally turned up portions of the freshwater and mud tortoises *Trionyx* and *Emys*.

This marl has an extensive range and may some time be of use

again; it extends from Whitecliff Bay to Headon Hill, by Hordle, Lymington, Brockenhurst, and Lyndhurst, and various other places in the New Forest; it is then lost until we reach Creechbarrow Hill, where we find it again in the disused marl-pits referred to above. At Cut-walk Hill, where it was once extensively worked, a part of the Middle Headon Series is passed through before reaching the marl. At the base we frequently find specimens of the beautiful little *Voluta geminata* and other marine shells. Sir Charles Lyell when a young man of about 17, crossing a field with some sportsmen, picked up several of those fossils, and about twenty years afterwards sent specimens to F. E. Edwards, who was then preparing his Monograph on the Eocene and Oligocene Mollusca. I was at that time living at Milford, and Mr. Edwards wrote asking if I would try to find the locality. This I did, and made a good collection of fossils from Cut-walk Hill, one mile and a half north of Lyndhurst. The Rev. O. Fisher and the Rev. John Compton, Rector of Lyndhurst, visited the localities with me and collected a considerable number of fossils. Sir Charles Lyell, Professor Prestwich, and Sir W. H. Flower also visited the place for the purpose of studying the formations. The Rev. O. Fisher will, I am sure, corroborate my statements respecting the digging of the marl and the finding of the fossils at Brockenhurst, Lyndhurst, and elsewhere in that district.

This, I believe, is the first time that the Oligocene formation has been shown to occur in the Isle of Purbeck, and it will now be seen that it had a much more extensive range than had previously been supposed. Beginning at Whitecliff Bay it runs across the larger part of the parish of Bembridge, over the Solent to Hordle, Lymington, Beaulieu, Brockenhurst, and Lyndhurst, and extends thence to Creechbarrow Hill, about 7 miles west of Studland Bay. When engaged in making a collection for the Marchioness of Hastings, I found at Efford Hill a disused marl-pit quite rich in vertebrate remains, and I there collected portions of a crocodile's jaw with teeth, various mammalian remains, with *Emys* and *Trionyx*. These specimens are now preserved in the British Museum (Natural History), South Kensington. The marls which are found between the 400 and 500 foot contour-lines I regard as Lower Headon, and are the same as those which were formerly so extensively worked for manuring the land. It can now be seen that if we allow this to be Lower Headon we have space enough between it and the top of the hill for the Middle and Upper Headon, the Osborne, and the Bembridge Series. By taking the average level of the Pipeclay Series, say at the 337 foot contour, we shall leave 300 feet to the top of the hill, and allowing 50 feet as the thickness from the Pipeclay to the top of the Lower Bagshot Series, we shall have 250 feet for the Bracklesham, Barton, and the whole of the Oligocene; from which it will be seen that the hill may contain all the formations which occur in the corresponding position in the Isle of Wight.[1] The sand and flints described by Mr. Hudleston, and

[1] The only formations which have not been satisfactorily proved to occur are the Bracklesham, the Barton, and the Middle and Upper Headon. I have no doubt that those could be found in the hill by the sinking of pits and perhaps of a few boreholes.



F. A. Brock del.

Fossils from the Bembridge Limestone, Creechbarrow Hill.

considered by him to be of Lower Bagshot age, I regard as Pleistocene drift, such as may be met with in many places, not only in the Isle of Purbeck, but in the New Forest and the Isle of Wight. At the Rabbit Warren at Headon Hill there is nearly or quite 100 feet of sand and flint gravel, the flints being in every respect exactly similar to those from Creechbarrow. One of the workmen picked up, at a depth of about 13 feet, in one of the pits a piece of Bembridge Limestone associated with the flints in the gravel, which is quite conclusive evidence that the gravel cannot be of Bagshot age.

In conclusion, I should like to thank Mr. A. H. Bloomfield for valuable assistance, and to assure any persons visiting the Isle of Purbeck for the purpose of studying its stratigraphy or collecting fossils that they would do well to secure his services.

EXPLANATION OF PLATE XXXIV.

Fossils from the Bembridge Limestone of Creechbarrow Hill, Purbeck, in the Sedgwick Museum, Cambridge, collected by H. Keeping.

FIGS. 1, 2. *Amphidromus* [*Bulimus*] *ellipticus* (Sowb.). 1, with shell preserved; 2, internal cast.
,, 3. Egg of *Amphidromus* (?).
,, 4. *Cyclotus cinctus*, Edwards; × 1½.
,, 5. *Helix occlusa*, Edwards.
,, 6. *Glandina* [*Achatina*] *costellata* (Sowb.).
,, 7, 8. *Clausilia striatula*, Edwards. 7, natural external cast, × 1½. 8, wax impression of external cast, × 1½.

III.—The Residual Earths of British Guiana commonly termed 'Laterite'.

By Professor J. B. Harrison, C.M.G., M.A., F.G.S., F.I.C., assisted by K. D. Reid, Assistant Analyst British Guiana.

On pages 20–2 and 99–105 of the *Geology of the Gold Fields of British Guiana* I gave a condensed account of the residual earths derived from the gradual decomposition of igneous rocks in situ which characterize wide areas in British Guiana as well as in the neighbouring countries of Venezuela, Dutch Guiana, French Guiana, and Brazilian Guiana. This deposit forms in many places a widespread very thick blanket-like coating to the igneous rocks from which it is derived, and owing in many places to its striking resemblance in general properties to the typical Indian formation described by Buchanan in 1807 it has been alluded to by many authors and by numerous mining engineers as 'laterite'. I gave on p. 101 two analyses of lateritic deposits which I selected from many I had made as showing the general composition of the earths. Unfortunately I omitted to show in them separately, as I had done in the original analyses, the proportions of silica present as quartz and of that present in a combined state. If I had done this it would have been seen that the earths contained but little combined silica and a relatively high proportion of alumina presumably present in the state of hydrate. For instance, in the Tumatumari sample which I collected myself from a deep cutting in the laterite lying on the diabase of the Tumatumari cataracts a few feet only above the surface of the unaltered rock, out of 51·76 per cent. of silica 49·35 is in the form of quartz, leaving 2·41 per cent. in the combined state in the presence of 24·55 per cent.